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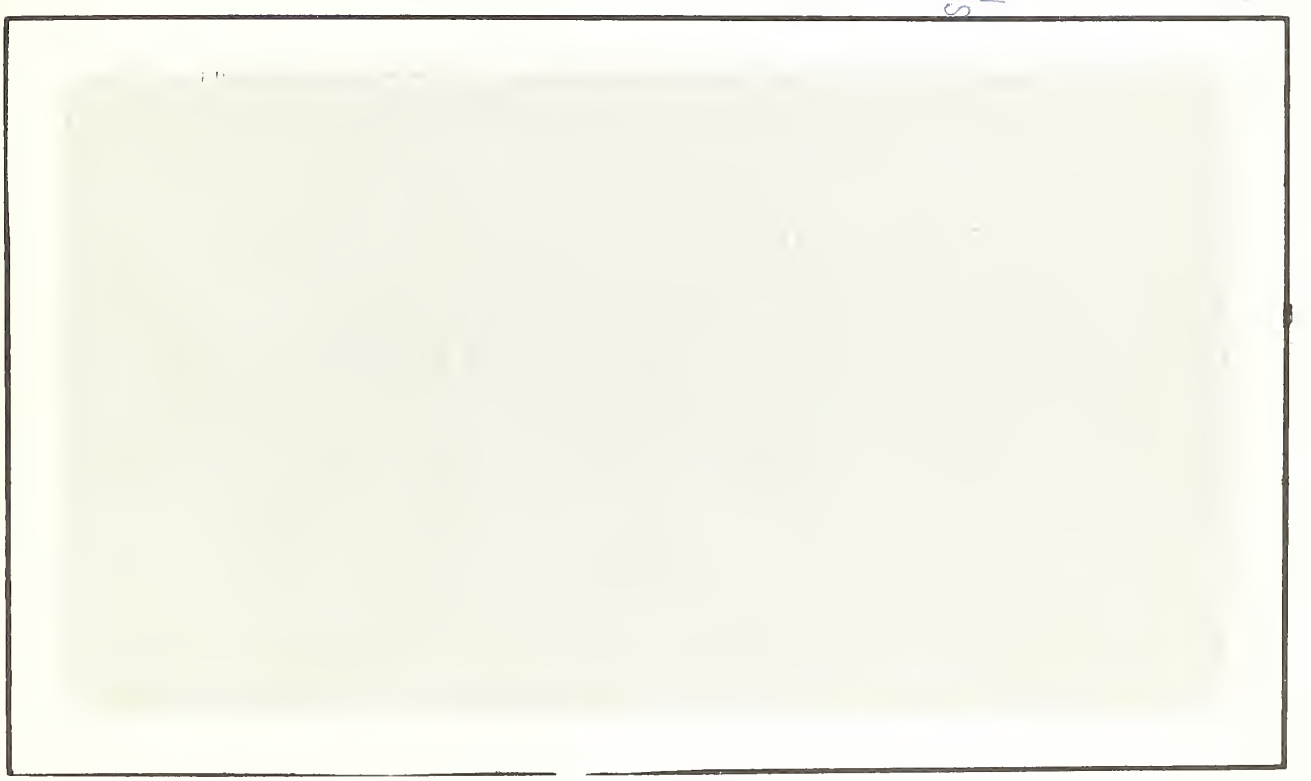

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Insect Pests and Diseases of the Pecan

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CONTENTS

ABSTRACT

The biology of and damage caused by some 40 insects and diseases are described, and general control measures outlined. In addition, tree injuries leading to disease are discussed. A key to the identification of various disorders is included. Indexed. Illustrated. Index terms: *Carya illinoensis* Koch, pecan diseases, pecan insects, pecans. *Address communications to Jerry A. Payne, Southeastern Fruit and Tree Nut Research Laboratory, P.O. Box 87, Byron, Ga. 31008.*

Introduction

The pecan, *Carya illinoensis* Koch, is grown principally across the southern United States in a belt that includes Alabama, Arizona, Arkansas, Florida, Georgia, Louisiana, Mississippi, New Mexico, Oklahoma, South Carolina, and Texas. Pecans are also grown in California, Kentucky, Missouri, Nebraska, North Carolina, Tennessee, and Virginia. The trees are attacked by numerous insects and diseases, they are subject to nutritional deficiencies, and their growth habit is altered by sudden changes in environmental conditions. Symptoms of different disorders are often similar, thus making diagnosis of the trouble difficult. Furthermore, interactions among causal factors can complicate control measures. It is important for the pecan grower to know how to distinguish various disorders and understand their causes so that proper control measures can be applied.

Not only do many kinds of pests attack pecan trees, they attack all parts of the tree—the bark and heartwood of limbs, roots, trunk, and twigs and the shoots, buds, leaves, and nuts. Some are present throughout the growing season, while others are found for limited periods, either early or late. The rapid growth of the pecan industry has brought about new problems in pest control. With the trend away from native stands, where every tree is genetically different, toward groves of uniform varieties, the damage caused is more severe. The pests multiply rapidly because large acreages of pecan groves provide the environment and an abundance of the food they prefer. Species that were not common in the past have moved to pecans from hickories and other host plants.

Most pecan diseases are caused by fungi that remain dormant during the winter in bark lesions, dead twigs, leaves and shucks, and other ground trash. In early spring, under warm humid conditions, the fungi begin active growth and produce spores that are quickly disseminated to growing tissue by rain, insects, and wind. New lesions are formed from this first cycle of spores and are the source of succeeding cycles of spores. The best means of control is by a fungicide spray program that starts in early spring, when buds are bursting and leaves are showing green, and continues throughout the season. The early sprays are probably the most important in protecting the current season's crop. However, sprays should be continued throughout the season to prevent late-season diseases and premature defoliation. The maintenance of healthy foliage late into the fall helps the current year's crop to mature and is necessary for next year's crop. Few nuts are produced on trees defoliated in August or September of the preceding year.

But it is often a waste of time and money to apply insect and disease control measures to poor varieties or to trees that lack vigor because of inadequate soil fertility, overcrowding, or general neglect. To produce profitable crops, the pecan grower must adhere to cultural practices that promote tree vigor, stimulate fruiting, and minimize the damage caused by pests. For example, trees weakened by inadequate nitrogen fertilization and rank weed growth are more susceptible to damage by some leaf-spotting fungi. Conversely, too much nitrogen, which promotes season-long growth, can produce tender shoots that are highly susceptible to the scab fungus. Many disease organisms thrive under conditions that favor summer growth flushes. Practices that allow good air circulation such as wide spacing of trees, removal of lower limbs, and maintenance of low ground cover and hedgerows in summer facilitate disease and insect control.

Ground sanitation is partially effective against most fungus diseases because the overwintering stage can often be eliminated. Ground trash such as broken limbs, shucks, and insect-infested nuts should be removed from the grove during the winter. Disking to turn under trash is not advisable unless no other means of debris disposal is available. (Disking can spread crown gall, and the resulting root pruning can lead to nutrient deficiencies, especially rosette.)

This publication is not concerned with specific chemical control; the grower should refer to State

extension service bulletins, which are updated often, or contact local extension service agents. Rather, our objective is to describe the biology of the insects and diseases and their symptoms in the grove and to outline general control measures. Constant observation of pecan groves throughout the season is absolutely essential for this information to be economically useful. As one successful pecan grower put it, "The best care a pecan tree can receive is the shadow of its owner."

Insect Pests

HICKORY SHUCKWORM

The hickory shuckworm, the larva of the moth *Laspeyresia caryana* (Fitch), is one of the most destructive insects that infest the pecan. It is generally distributed throughout the Pecan Belt, from Georgia and South Carolina in the east through Texas in the west. Shuckworms also feed on hickory nuts, causing injury similar to that found on the pecan. The shuckworm is primarily a nut-infesting pest, but it is commonly found feeding in phylloxera galls on pecan in early spring.

Hickory shuckworms attack the nuts from about the first of June until harvest. From the time of first appearance until shell hardening late in August, these insects can continually destroy the interior of the nuts (fig. 1). Immature nuts infested early in the season fall to the ground. It is usually difficult to see the entry holes made by shuckworms except under magnification. Their presence, however, may often be detected in newly dropped nuts by a powdery white stain around the entry point. Much of the crop may be lost to shuckworms, especially when there is a light nut set.

After shell hardening, shuckworms tunnel in the green shucks and prevent the kernels from developing properly. Infested nuts may be poorly filled and may mature later than healthy nuts.

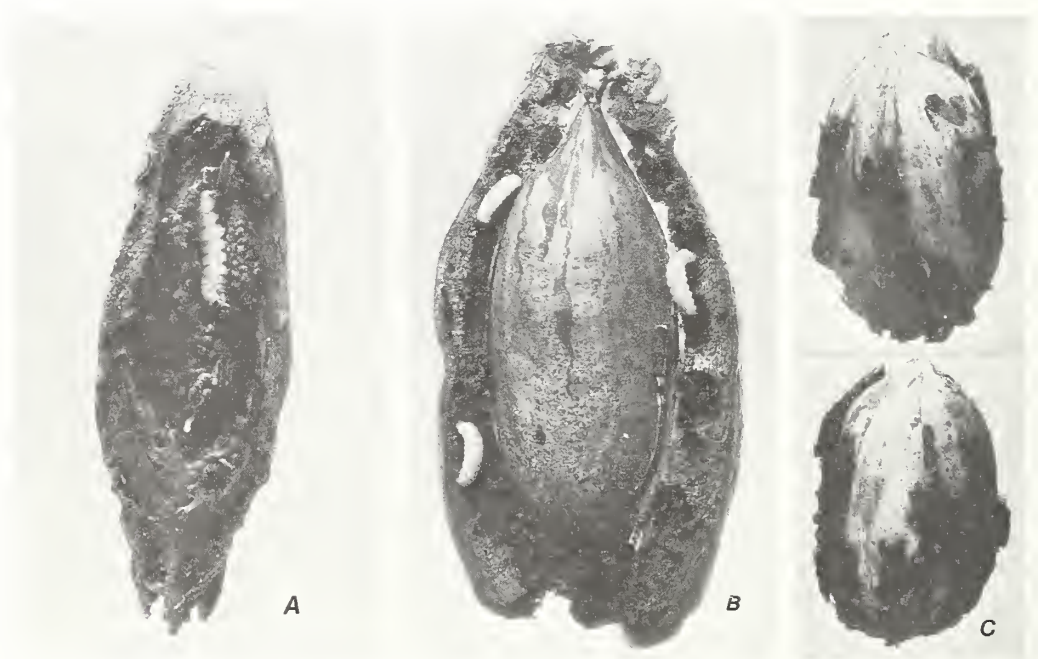

FIGURE 1.—Damage caused by the hickory shuckworm. *A*, Larva in an immature nut. *B*, Larvae mining the shuck of a nearly mature nut. *C*, Nut showing shell stains and adhering parts of damaged shuck.

FIGURE 2.—Moth of the hickory shuckworm resting on developing nut. The moth is about three-eighths inch long.

Injured portions of the shucks stick to the nuts and interfere with processing, and the shells are often badly stained.

Full-grown shuckworms overwinter in shucks on the ground or on the tree. They are one-third to one-half inch long and creamy to dirty white, with brownish heads. They pupate within the shuck in late winter and early spring and then metamorphose into inconspicuous moths (fig. 2), dark brown to smoky black, about three-eighths inch long, with ½-inch wingspans.

In northern Florida and southern Georgia, the moths begin to appear in mid-February, but most moths of the first generation emerge in April, and a few continue to appear well into summer. The spring development of the insect coincides with that of the native hickory nuts on which the early moths lay eggs. The hickories set fruit 2 to 3 weeks earlier than the pecan. The late-emerging moths of the spring brood lay their small, whitish, flattened eggs on the foliage and small nuts of the pecan. Few pecan nuts become infested with shuckworms before June because most of the spring brood of moths dies before the nuts set. Starting in June, the shuckworm population increases rapidly, with as many as four or five successive generations found in southern Georgia.

Growers with few trees and those not equipped to spray may reduce infestation by gathering and destroying pecan shucks at harvest. Plowing the shucks under in early spring may aid control. The drops (small nuts) should be gathered and burned during midsummer. Proper insecticide application can reduce shuckworm populations to an insignificant level.

FIGURE 3.—Pecan foliage damaged by pecan bud moth larvae.

PECAN BUD MOTH

The larvae of the pecan bud moth, *Gretchena bolliana* (Slingerland), often cause serious damage to pecan nursery stock by feeding on terminal buds and foliage (fig. 3). The damage causes excessive branching and stunted growth in young pecan trees. The larvae occasionally defoliate large pecan trees, feed on young nuts in spring, and infest the shucks in fall.

The adult is a small gray moth with blackish-brown patches on the forewings. Its wingspan is about two-thirds of an inch. The insect overwinters as an adult. The moths begin laying eggs on the twigs near buds when the buds open in spring. When foliage appears, they lay more eggs on the upper surfaces of the leaves. The larvae, about one-half inch long, are creamy to dirty white at first, becoming yellowish green, with dark-brown heads and necks. After feeding for 25 days, they pupate in rolled-up leaves or infested buds,

but occasionally under bark scales. There are probably five or six generations each year.

Vigorous young nursery trees, kept healthy by proper cultivation and fertilization, usually recover from bud moth attack better than weak ones. The terminal buds unfold so rapidly that the larvae do not have time to inflict serious damage. Control is seldom necessary in bearing groves. If bud moth damage is apparent, apply a recommended insecticide.

FIGURE 4.—Winter cocoon (arrow) of the pecan nut casebearer at the base of a bud.

FIGURE 5.—Moth of the pecan nut casebearer on small nut. The moth is about one-third inch long.

PECAN NUT CASEBEARER

The pecan nut casebearer, the larva of the moth *Acrobasis nuxvorella* Neunzig, causes damage throughout the Pecan Belt. Losses vary with the size of the crop. A light-to-moderate infestation in a heavy set of nuts may merely provide desirable thinning, but most nuts may be destroyed in a light crop.

Partly grown casebearers pass the winter in small, tightly woven cocoons (fig. 4) called

FIGURE 6.—Egg (arrow) of pecan nut casebearer at calyx end of small pecan nut. Nut casebearer eggs are approximately one-fiftieth of an inch long.

hibernacula, usually found where a bud joins the stem. The casebearers become active in spring about the time the buds begin to open. They feed first for a short time on buds, then bore into the young tender shoots, where they pupate. Full-grown casebearers are about one-half inch long and have olive-green to jade-green bodies with yellowish-brown heads.

The adult moth is small (one-third inch long), inconspicuous, and dark gray, with a ridge, or tuft, of dark scales extending across the forewings near the middle (fig. 5). The moths usually emerge in May and are most numerous about the time of nut set. They lay greenish-white oval eggs on the blossom end of the nut, usually near the base of the calyx lobes (fig. 6). Commonly, only one or two eggs are laid in a cluster of nuts.

The first-generation larvae cause most of the damage in May and June. Newly hatched casebearers descend from the nut clusters to feed on the buds just below. A few days later, they return to the clusters and attack the newly set nuts, normally entering them at the stem end. Infested nuts are held together by silken threads (fig. 7) and are easily recognized by the conspicuous frass cast out by the larvae. In the course of its development, a single casebearer of this generation may destroy all the nuts in a cluster. Larvae mature and pupate in one of the last nuts they attack (fig. 8).

Second-generation moths appear in late June and early July. Larvae of this generation also attack the nuts, but the loss is less because the nuts are larger, and an individual casebearer requires fewer nuts for its development. Larvae of later generations feed mostly on the shuck surfaces and to some extent on the leaves, but do little damage. Larvae of the last generation in the season overwinter in cocoons constructed about the buds. Three generations of this insect are most common, although four have occurred in Texas.

Growers should spray with the recommended pesticides if over 3 percent of the previous year's shoots are infested with overwintering larvae or if there is a history of serious infestation.

FIGURE 7.—Cluster of nuts infested by the pecan nut casebearer. Note the silken threads holding nuts together.

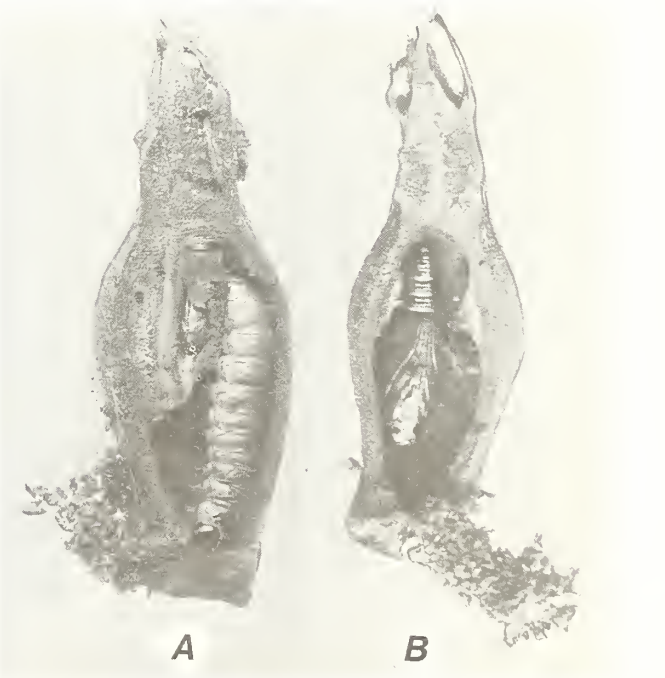

FIGURE 8.—Larva (*A*) and pupa (*B*) of the pecan nut casebearer within small nuts.

PECAN WEEVIL

The pecan weevil, *Curculio caryae* (Horn), is a light-brown or grayish beetle about one-half inch long, with a long beak (fig. 9). The beak of the female is slightly longer than the body, while that of the male is about half as long. This insect at-

tacks the pecan nut, causing serious crop losses in many areas of the Southeastern States and in Texas and Oklahoma.

The weevils do not ordinarily move far from the tree under which they emerge from the soil, provided there is a crop of nuts on that tree.

FIGURE 9.—Pecan weevils on 'Schley' pecans. The female (lower left) has a longer beak than the male.

Consequently, certain trees may be heavily infested year after year, while other trees of the same variety close by may receive little damage. Weevils apparently prefer trees growing in low areas and those adjacent to hickory trees.

Pecan varieties differ widely in their susceptibility to attack. Early-maturing varieties such as 'Mahan', 'Moneymaker', 'Schley', and 'Stuart' are most commonly infested. Late-maturing varieties such as 'Mobile', 'Teche', and 'Van Deman' are usually not attacked unless the crop of early-maturing varieties is light or destroyed before the insect completes feeding and egg laying. Most hickory nuts are attacked.

Adult weevils emerge from the soil at various times. In central Georgia they usually emerge between August 1 and September 15, and in central Texas, in August or early in September after periods of heavy rainfall. At the time of kernel formation near the end of August, the females drill holes through the shucks and shells with their long beaks and place two to four eggs in separate pockets within the kernels.

Pecan weevils cause two kinds of nut damage, depending on the stage of nut development at the time of attack.

The first kind of damage is caused by adult weevils feeding on kernels in the water stage, before shell hardening. This feeding generally results in a drop of all punctured nuts, but the

FIGURE 10.—*A*, Nearly mature grubs of the pecan weevil within 'Stuart' pecan. *B*, Grub emerging through hole in nut. *C*, Nut with hole through which mature grub may escape.

infestation may pass unnoticed because other insects and factors can also cause a premature nut drop. Weevil-punctured nuts can be identified by a tobaccolike stain around the feeding site. Dark patches develop on the nut surface, and in a few days the nuts drop from the trees.

The second kind of damage is caused by weevil grubs, or larvae, feeding in the partially matured nuts. Damaged mature nuts bleed little and do not drop. The grubs feed on the kernels for several weeks (fig. 10). When fully grown, about three-fifths inch long, the creamy-white grubs with reddish-brown heads leave the nut through circular holes about one-eighth inch in diameter. Infested nuts are worthless since the larvae normally destroy the kernels, and the shucks often adhere to the shell. This damage is noticeable at harvesttime and may destroy practically the entire crop in seasons when large numbers of weevils are present.

Most grubs leave the nuts between the last of September and the last of December, but some may be later. They enter the soil to a depth of 4 to 12 inches and construct earthen cells, where they remain in the larval stage 1 or 2 years. They pupate between the first part of September and the middle of October and metamorphose into adults in about 3 weeks. These adults remain in the soil until the following summer. The complete life cycle requires from 2 to 3 years.

Growers not prepared to spray and those with dooryard trees can reduce weevil injury by placing harvesting sheets under trees and lightly jarring the limbs to shake the weevils free. It may be necessary to climb the trees to reach upper portions. The dislodged beetles usually remain still and can be collected easily. They should be killed by crushing or by immersing in kerosene.

Begin shaking the weevils out of trees in early August in Georgia, Alabama, Mississippi, Louisiana, and North and South Carolina. Begin after the first heavy rain in mid-August or early September in Texas. This should be repeated weekly until about September 15 or until no weevils are recovered. To determine the presence of weevils, jar a few of the trees known to be the most heavily infested year after year. If the weather is dry, few weevils will be collected, and frequent shaking of trees is not necessary until rain softens the ground.

STINK BUGS AND OTHER PLANT BUGS

The southern green stink bug, *Nezara viridula* (Linnaeus), the leaffooted bug, *Leptoglossus phyllopus* (Linnaeus), and similar sucking insects cause black pit and kernel spot of pecan nuts (fig. 11). Darkened insides of immature nuts, known as black pit, indicate stink bug feeding before shell

FIGURE 11.— Left, Southern green stink bug. Right, Leaffooted bug.

FIGURE 12.—Kernel spot on ridges and edges of 'Schley' pecan kernels.

hardening. This feeding causes premature dropping. Brown or black stains sometimes develop on the shuck at the puncture site, and soon after the nuts drop, these spread over the entire shuck surface. Stink bug damage is similar to that of pecan weevil and hickory shuckworm. Stink bug punctures occurring after shell hardening do not cause nut drop. However, brown spots from one-sixteenth to three-sixteenths inch in diameter, forming a pithy, porous area (fig. 12) known as kernel spot, are seen after shelling. The spots produce a localized bitter taste that does not extend to the rest of the kernel. The severity of damage varies with the number of plant bugs in a grove. The abundance of bugs depends on the presence of the native plants or cover crops on which they breed.

The various plant bugs that cause black pit and kernel spot have similar life habits. The southern green stink bug, which is the most prevalent, is shield shaped, light green, and about one-half inch long. The adult passes the winter in trash or similar shelter in or near the grove. It lays eggs in clusters in early spring under the leaves of weeds, cover crops, or other low-growing plants, where the bugs feed until they are fully grown. There may be up to four generations in a year. Pecan nuts are attacked only by the mature bugs, which fly to the trees from the surrounding cover crop.

The natural history of the leaffooted bug is similar. The leaffooted bug is about one-half inch long, light to dark brown, and narrower in body outline than the green stink bug. The leaffooted bug has a flattened leaflike segment in the hind legs. It breeds on thistle, yucca, basket flower, jimsonweed, and cowpea.

The avoidance of summer cover crops such as cowpeas, soybeans, or crotalaria and garden crops such as okra, beans, pumpkins, squash, and tomatoes near pecan groves will help control plant bugs. Winter cover crops such as hairy vetch or reseeding crimson clover are safe to use. Till the soil or mow the grove during the summer to destroy wild hosts such as beggarweed, thistle, jimsonweed, and maypop. Winter sanitation will kill many of the hibernating adults. Fence rows in particular should be cleared.

CURCULIOS

Two species of curculios, *Conotrachelus aratus* (Germar) and *C. hicoriae* (Schoof), attack pecan. These beetles are three-sixteenths inch long and dark gray to reddish brown. They have slightly curved snouts approximately one-third the body length.

C. hicoriae, the so-called nut curculio, attacks several varieties of immature pecan nuts from late June through early August in some parts of Louisiana, Georgia, Arkansas, and Mississippi. The adult curculio deposits a single egg in the shuck of each nut during late June or early July. The curculio puncture and larval feeding within the shucks cause a bleeding of brown sap (fig. 13) on the shuck and premature nut drop similar to that caused by the pecan weevil. Like shuckworms, the creamy-white legless larvae continue to feed in the dropped nuts for about 2 weeks before leaving the nut. They form a pupal cell under the nut in the upper 2 to 4 inches of the soil. The adults emerge from August to October. The insect produces but one generation a year.

When trees have a good nut crop, *C. hicoriae* damage may go unnoticed or be attributed to hickory shuckworms. Chemical spray may be necessary when jarring the tree indicates the presence of many adults.

The hickory shoot curculio, *C. aratus*, feeds and lays eggs in the unfolding buds and young shoots on pecan during late March and April in

FIGURE 13.—Immature pecans injured by nut curculio often bleed and accumulate a tobaccolike deposit (arrows).

FIGURE 14.—Spittlelike substance produced by spittlebugs on pecans.

some areas of the Pecan Belt. Severe infestations occur most commonly on unmanaged trees or in groves adjacent to woodlands containing native pecan and hickory trees. Fifty percent or more of the shoots can become infested. The females deposit eggs in shallow cavities in the bark of tender twigs and leaf petioles. The bark around the egg cavity later turns dark, and the injury appears as a blackish triangular spot. The larvae tunnel within the shoots and leaf stems near the point of attachment to the shoot, resulting in premature foliage loss and weakening of nut-bearing shoots. The legless creamy-white larvae are three-sixteenths inch long when fully grown. They pupate in soil beneath the infested tree, and the adults emerge in August and September. Adult curculios overwinter in debris in the grove.

The hickory shoot curculio is usually not a pest in managed groves, but chemical control may be necessary if jarring the tree indicates that many adults are present or if there is a history of damage. Sprays should be applied when unfolding buds have one-fourth to 1 inch of green growth.

SPITTLEBUGS

The pecan spittlebug, *Clastoptera achatina* Germar, and the alder spittlebug, *C. obtusa* (Say), are common on pecan trees along the gulf coast, up the Atlantic coast from Florida to Massachusetts, and westward to Kansas. They are prevalent in parts of Kentucky and Illinois.

Groups of young bugs (nymphs) clustered together produce masses of white frothlike exudate about the buds, tender shoots, and nut clusters (fig. 14). They are commonly found in spring, beginning shortly after the nuts have set, and again in midsummer. They suck the juices from tender growth, and heavy infestations kill the terminal shoots, resulting in a reduced crop.

The adults, about one-fourth inch long, are commonly called froghoppers because of their resemblance to frogs. They are pale brown with a reddish tinge and have darker brown areas on the forewings. In late June and early July, they deposit several eggs in small slits in the bark of twigs of the previous season's growth. There are two generations each year, and the insect overwinters as an egg.

Large populations of spittlebugs require chemical control. Light infestations generally do not cause sufficient damage to make control necessary.

APHIDS

Several aphid species infest pecan trees, but the most common are the black pecan aphid and the yellow aphids. Practically all important pecan varieties over the entire Pecan Belt are attacked by these aphids, and heavy infestations in late summer may cause defoliation and reduce the nut

FIGURE 15.—Pecan leaf injured by the black pecan aphid. Note aphids (black spots) on injured areas (light areas).

crop in the current and succeeding years. Large aphid populations require chemical control, but indiscriminate use of fungicides and insecticides kills predaceous insects, parasites, and entomogenous fungi that help keep aphids in check naturally.

BLACK PECAN APHID

The black pecan aphid, *Melanocallis caryaefoliae* (Davis), is considered more destructive than other aphid species because its feeding may cause

FIGURE 16.—Pecan trees defoliated by the black pecan aphid.

defoliation in a short time. The first signs of feeding are bright-yellow rectangular areas on the leaflets (fig. 15). These yellow areas (up to one-fourth inch in diameter) eventually turn brown, and the entire leaf may drop prematurely. Black aphids feed on both sides of the leaflet and prefer the shaded, inner portion of the tree. As injured leaflets drop, the aphids migrate toward the outside of the tree. Premature dropping of many leaves reduces the supply of plant food, prevents proper nut filling, and reduces the following year's bloom (fig. 16).

The black pecan aphid passes the winter in the egg stage in crevices in the bark. Late in March the eggs hatch into wingless aphids, which move out to the opening buds and leaves, where they feed until fully grown. Initially the aphids are light green, but after a short feeding period they become dark green to almost black. The adults have a series of large black tubercles on the back and sides. When fully grown, about one-sixteenth inch long, they give birth to living young. Some aphids develop wings and fly to other parts of the same tree or to other trees.

About 15 successive generations occur through the summer, and each mature aphid produces about 60 young. Under favorable conditions, a heavy infestation may develop from a low population within 3 or 4 weeks. Groves should be examined weekly from July through September to detect such increases before they become dangerously high. With the onset of cold weather, the insects lay eggs for the overwintering generation.

FIGURE 17.—Fall webworms in their web.

FIGURE 18.—Moth and egg mass of the fall webworm.

YELLOW APHIDS

There are at least two species of yellow aphids: the blackmargined aphid, *Monellia caryella* (Fitch), and yellow hickory aphid, *Monelliopsis nigropuncta* Granovsky. The adult aphids feed almost exclusively on the underside of leaflets. The extent of their injury is unknown, but they excrete large quantities of honeydew (sugar removed from leaflets), which produces a sticky siruplike film on the leaflet surface and supports the growth of a black sooty mold. The black coating can seriously interfere with normal leaflet functions. The life cycle of these aphids is similar to that of the black pecan aphid.

FALL WEBWORM

Fall webworms, the larvae of the moth *Hyphantria cunea* (Drury), feed in colonies, producing large dirty-white webs on pecan trees in late summer and fall (fig. 17). These caterpillars hatch from a mass of greenish-white eggs deposited on a leaf by a single moth (fig. 18). They feed on both surfaces of the leaves and enlarge the web as they spread.

The fully grown caterpillars, about 1 inch long, are covered with long white and black hairs. They spin flimsy hairy cocoons beneath loose debris near the surface of the soil. Adult moths, with a wingspan of about 1 inch, are usually white and often have a few black or brown spots on the forewings. Usually there are two broods a year, the second feeding late in the summer and in the fall. The insect overwinters as a pupa, and moths appear during the following year in April and May.

Control is necessary only when the insects are numerous in a grove, but it should be done when the caterpillars are small. It may be practical to remove the webs of small populations from the trees before the caterpillars have left them—preferably before they have done much feeding. A long-handled tree pruner or a bamboo pole with a hook at the end is a suitable tool.

WALNUT CATERPILLAR

Walnut caterpillars, the larvae of the moth *Datana integerrima* Grote & Robinson, feed in groups, often eating all the leaves on small trees or on individual limbs of large trees (fig. 19);

FIGURE 19.—Colony of walnut caterpillars on a pecan shoot.

FIGURE 20.—Walnut caterpillars clustered on trunk of pecan tree.

however, they do not form webs on the leaves. The immature larvae are reddish brown, with narrow cream-colored lines that extend the length of the body. The full-grown caterpillars are black, nearly 2 inches long, and thickly covered with long dirty-white or grayish hairs.

In southern regions the first generation appears in June and July, and the second generation, in late August and September. In preparation for molting, the caterpillars move down to a large limb or to the trunk and form a compact mass (fig. 20). After shedding their skins (fig. 21), they migrate back toward the ends of the branches and resume their feeding. The caterpillars molt several times during development. The walnut caterpillar overwinters in the pupal stage in the soil, much like the fall webworm.

The moths emerge in the spring and deposit white eggs in masses on the undersides of leaves. The light-brown moths have a wingspan of 1½ to 2

FIGURE 21.—Cast skins of walnut caterpillars on trunk of young pecan tree.

inches; the forewings are light brown with darker wavy lines conspicuously bordered with white.

Spray treatments similar to those recommended for the fall webworm will control this insect. Caterpillars clustered on the trunk or limbs of a tree may be destroyed by crushing or burning.

PECAN CIGAR CASEBEARER

The pecan cigar casebearer, the larva of the moth *Coleophora laticornella* Clemens, usually a minor pest, can sometimes seriously damage pecan buds and foliage during the spring months. The insect also feeds on hickory and black walnut. Generally distributed over the entire Pecan Belt, it is more common along the gulf coast.

Partly grown casebearer larvae pass the winter attached to a limb or twig in a light-brown case resembling a small ¼-inch-long cigar (fig. 22). As the pecan buds open, the casebearers become active and feed on the buds and foliage until mid-May, producing many tiny holes in the foliage.

FIGURE 22.—Numerous cases of pecan cigar casebearer attached to winter twigs.

FIGURE 23.—Pecan leaflet injured by the pecan cigar casebearer. Casebearers construct small cigar-shaped cases (top leaf) during the early summer months.

The larvae pupate within the cigar-shaped cases. The small brownish moths, with a wingspan of one-half inch, appear in early June and lay their eggs on the leaves. The larvae first feed as leaf-miners (fig. 23), but later in the season they construct the small cases in which they feed until foliage drop. The larvae then migrate to the twigs or larger limbs and attach their cases. There may be several generations during the season.

Sprays applied for control of the nut or leaf casebearer will normally suppress the cigar casebearer.

PECAN LEAF CASEBEARER

The pecan leaf casebearer, the larva of the moth *Acrobasis juglandis* (LeBaron), occurs commonly in northern Florida and the southern parts of Georgia, Alabama, Mississippi, Louisiana, and Texas. The immature casebearers overwinter near buds in small cocoons similar to those of pecan nut casebearers (fig. 24). In spring, the small brown larvae leave their winter cocoons, or hibernacula, and attack the unfolding buds and foliage (fig. 25). Heavy spring infestations of casebearers can keep pecan trees in a semidefoliated condition for 3 to 5 weeks. This injury often increases nut drop.

FIGURE 24.—Winter hibernacula, or cocoons, of pecan leaf casebearer around a pecan bud.

Leaf casebearers, about one-half inch long, are dark green and have shiny dark-brownish heads when mature. They pupate within the gray cases, five-eighths inch long, that they construct about themselves while feeding. The small grayish-brown moths, with a wingspan of two-thirds inch, appear from about mid-May until early August (fig. 26). The moths deposit eggs on the underside of leaflets along a vein or near the junction of a vein with the midrib. Newly hatched larvae, rarely longer than one-sixteenth inch by fall, feed sparingly on the undersides of the leaves from mid-May until November (fig. 27). The immature larvae leave their little winding cases on the undersurfaces of the leaves beginning in late August or early September and migrate to the buds, where they construct their winter cocoons. The insect has one generation a year.

Leaf casebearers can be controlled by spraying the trees early, when the buds begin to open, and in the summer from late June until mid-August. One application is normally sufficient if the undersides of the leaves are well covered.

FIGURE 25.—Young pecan buds injured by pecan leaf casebearers.

FIGURE 26.—Moth of the pecan leaf casebearer on pecan leaflet.

LEAFMINERS

Leafminers, the larvae of various moths, are among the smallest plant-feeding insects. They find both food and shelter in the thin space between the upper and lower surfaces of a single pecan leaflet. Each larva consumes only a small quantity of leaf during its growth, but the damage

FIGURE 27.—Feeding cases and injury to underside of pecan leaflet by newly hatched pecan leaf casebearer.

FIGURE 28.—Pecan leaflets with numerous serpentine mines of *Stigmella juglandifoliella*. The larvae make narrow winding galleries and avoid crossing the larger leaflet veins and midrib.

FIGURE 29.—Pecan leaflet with four blotch mines (arrows) of *Cameraria caryaefoliella*, showing the progression from the flat, epidermal, linear type to the mature irregular blotch.

caused by excessive numbers and successive generations cannot be disregarded. Heavy infestations of these insects may defoliate pecan trees during late summer and fall. Leafminers are widespread and have been observed in both the eastern and western United States on hickory, walnut, and butternut, but economically damaging infestations are not common.

The pecan serpentine leafminer, *Stigmella juglandifoliella* (Clemens) (fig. 28), is found wherever pecans are grown. The female moth lays minute, oval, flat, shiny eggs on the upper surface of pecan foliage during late May or early June. The pale-yellow larvae that hatch from these eggs are about one twenty-fifth inch long. They confine their feeding to the chlorophyll-containing cells just beneath the upper surface of the leaf, making a linear, or serpentine, mine about 2 inches long and one-twelfth inch wide, whitish to light tan in color, with a black line of frass running through the center. The mature light-green larvae (one-fifth inch long) cut a crescent-shaped slit in the upper leaf surface at the end of the mine and crawl out to pupate in the ground litter. They spin a light-tan to reddish-brown foot-shaped cocoon from which a small purple and white moth with a wingspan of one-eighth inch emerges within a week. Four generations of leafminers are produced in the Southeast during the summer.

Two other leafminers, *Cameraria caryaefoliella* (Clemens), which forms an upper-surface blotch mine, and *Phyllonorycter caryaealbella* (Chambers), which forms a lower-surface blotch mine, are also found on pecan (fig. 29). When the blotch mines are fresh, the separated leaf cuticle is a noticeable whitish color, commonly referred to as a frog eye.

Light infestations of leafminers do not cause sufficient damage to warrant control expense. Insecticides used for aphids or hickory shuckworms will usually control these pests.

PECAN CATOCALAS

The larvae, or caterpillars, of two species of catocala moth, *Catocala maestosa* (Hulst) and *C. viduata* (Guenee), are occasionally found on pecan foliage in the spring (fig. 30). When abundant, these caterpillars cause considerable damage by stripping the leaves until only the stem and petiole remain. The full-grown caterpillars are dark gray and 2½ to 3 inches long. Since their color closely resembles that of the bark, they often

FIGURE 30.—Full-grown larvae of *Catocala maestosa*.

escape detection. They are active when disturbed and move with a looping motion.

The moths deposit eggs on the underside of bark scales in the fall. Caterpillars hatch the following spring and feed on the foliage throughout the spring and early summer. They pupate in flimsy silken cocoons attached to leaves. The moths appear in late June and continue to emerge through autumn.

These insects are rarely abundant enough to require special control measures. Natural insect predators usually keep them in check.

MITES

Although mites are not insects, they are closely related. Several species attack pecan trees throughout the Pecan Belt. The most common and injurious is *Eotetranychus hicoriae* (McGregor), the pecan leaf scorch mite (fig. 31). Heavy infestations of this mite cause serious foliage loss. It is pale green and barely visible to the naked eye. It feeds primarily on the undersides of the leaves, but occasionally may be found on the upper sides.

Affected leaflets show a slight discoloration about the midribs, where the mites usually begin feeding. Later, the discoloration spreads outward,

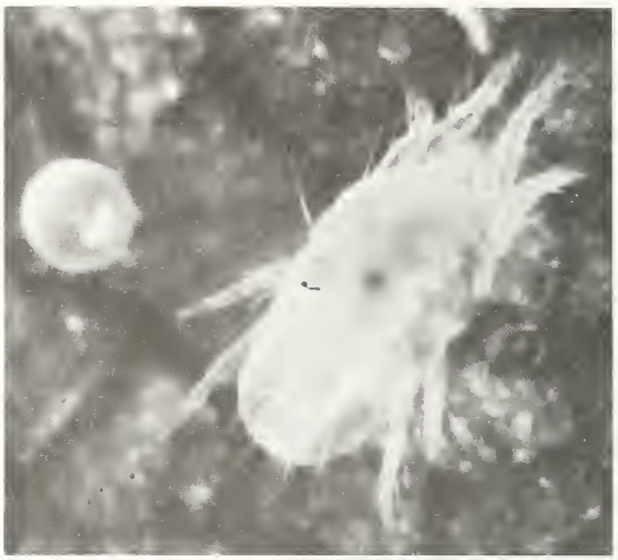

FIGURE 31.—Pecan leaf scorch mite, adult and egg on pecan leaflet. This tiny pale-green pest is 1/125 of an inch long.

and the leaflets appear scorched. Early scorch symptoms are dark-brown or liver-colored blotches, later developing into dead areas of irregular size and pattern. Severely injured leaflets turn brown and drop off. Infestation generally starts on the lower branches of pecan trees and spreads upward. Injury has been observed in June, but is usually more severe from late summer to frost. The mites develop rapidly in hot dry weather and produce several generations each year.

Other mite species are sometimes found, particularly in Louisiana and Texas. *Aceria caryae* (Keifer) feeds on the margins of leaflets, causing a gall-like roll. *Brevipalpus* spp. feed on the undersides of the leaflets near the veins, causing the adjacent tissue to turn brown. *Oligonychus viridis* (Banks) feeds on the upper side of leaflets, resulting in damaged chlorophyll and a grayish color.

Treatment for mites can be combined with that for aphids and with disease controls needed at or near the same time.

PHYLLOXERAS

Tumorlike swellings, or galls, one-tenth to 1 inch in diameter occasionally appear on leaves, leafstalks, succulent shoots, and nuts of new growth (fig. 32). These green or yellowish-green galls are caused by small soft-bodied sucking insects known as phylloxeras, which are closely

FIGURE 32.—Phylloxera galls on a pecan twig.

FIGURE 33.—Galls of pecan leaf phylloxera on pecan leaflets.

related to aphids. Several species are found in almost all sections of the Pecan Belt, but the pecan phylloxera, *Phylloxera devastatrix* Pergande, is most damaging. This insect causes malformed, weakened shoots, which finally die. Severe infestations can destroy entire limbs. Serious damage has been reported in Arkansas, Louisiana, Mississippi, Oklahoma, and Texas.

The insect overwinters in the egg stage in protected places on the branches. The young appear in spring about the time the buds unfold. The insect inserts its beak into the new growth, causing a gall to form that soon envelops the insect. The insect matures within the gall, lays a large number of eggs, and then dies. After the young insects (nymphs) that hatch from these eggs develop into adults (winged forms), the gall splits open and releases the insects, usually in late May or early June. There are several generations each year.

The pecan leaf phylloxera, *Phylloxera notabilis* Pergande, is usually not considered a serious pest of mature pecan trees, but it can damage young nursery trees. Feeding on new spring growth results in $^1/_8$- to $^1/_4$-inch green galls on leaves only (fig. 33). The life cycle is similar to that of the pecan phylloxera.

For chemical control of pecan and leaf phylloxeras, spray trees with a recommended insecticide or dormant oil.

MAY BEETLES

May beetles, *Phyllophaga* spp., sometimes defoliate pecan trees in spring. Small trees surrounded by uncultivated land are most susceptible to injury. The beetles feed at night on

FIGURE 34.—May beetles.

young leaves and newly opened buds, while in daytime they lie hidden just beneath the surface of the ground.

The adult beetles (fig. 34) are one-half to three-fourths inch long, robust, and usually light to dark brown. They lay their eggs in the ground and the larvae, known as white grubs, feed on the roots of plants, particularly grasses.

Grubs seldom cause injury in well-cultivated groves located some distance from uncultivated land. Pastures near groves are a source of infestation, but if the soil is plowed once a year, the May beetles are not numerous. Beetles on small trees may be shaken onto sheets on the ground at night and destroyed. Where cultivation is impractical, insecticide sprays may be needed.

SAWFLIES

Adult sawflies, *Periclista* spp., small beelike insects about one-fifth inch long, emerge from the ground in April and deposit small pale-green eggs in the tissue of pecan leaflets. The spiny leaf-green sawfly larvae are about one-tenth inch long upon hatching and are about five-eighths inch long when fully grown. Sawfly larvae generally feed on the underside of the foliage, where they chew holes in the leaves. Feeding holes are very small at first, but increase in size as the larvae develop (fig. 35). Their feeding gives the leaves a shotlike or lacy appearance. When the larvae are through feeding, they enter the soil to a depth of 1 to 3 inches, where they construct earthen cocoons in which they spend the winter.

Control is seldom necessary. Sprays applied for control of other pecan pests normally suppress sawfly outbreaks.

TWIG GIRDLER

The adult twig girdler, *Oncideres cingulata* (Say), often girdles the twigs of pecans and other trees late in summer and during fall (fig. 36), causing the injured branch to break off or hang loosely on the tree. This insect is generally present wherever pecans are grown. It is especially abundant in groves near timberland containing hickory and persimmon.

Twig girdlers are grayish-brown beetles, one-half to five-eighths inch long, with reddish-brown

FIGURE 35.—Sawfly-feeding injury on pecan foliage.

FIGURE 36.—Twig girdler girdling a pecan branch.

heads bearing long antennae. They lay eggs, which hatch into whitish legless grubs, in the twigs that they girdle. The grubs grow slowly during the fall and winter months, but in spring, as they begin to tunnel into twigs, they grow rapidly. They complete their growth, pupate, and metamorphose into beetles during the latter part of August. Commonly, they complete the life cycle in 1 year, although some individuals require a second season.

Severed branches lodged in the trees, those on the ground, and those from infested nearby woodlot trees should be gathered and burned during the winter, when the eggs and grubs are in the twigs. Spray with a recommended insecticide to prevent damage in groves that have a history of infestation.

OBSCURE SCALE

The obscure scale, *Melanaspis obscura* (Comstock), is found in most areas of the Pecan Belt, and it is a serious pest of pecans in Texas, Louisiana, Arkansas, and Mississippi, often requiring chemical control. Its body, about one-eighth inch long, is covered with a circular dark-gray scalelike substance. Its body coloration is similar to that of the bark, making detection difficult. It attacks both branches and tree trunk. The bark of heavily infested branches appears roughened or scaly (fig. 37).

The scale sucks the sap from plant tissues, and this can gradually kill branches less than 3 inches in diameter. Larger branches are seldom killed, though they may be so weakened that they will not produce a normal crop. Slow, progressive destruction of infested branches reduces the number of fruiting shoots and weakens the tree, making it subject to attack by boring insects.

Scale produces only one generation each year. The young, called crawlers, are present from about the middle of May until early August. Soon after they hatch, the crawlers settle on the bark, insert their beaks, and begin to form their waxy scale coverings. They gradually increase in size and, except for the adult males, do not move around. Female scales overwinter under their scaly covering on bark.

FLATHEADED APPLETREE BORER

The flatheaded appletree borer, the larva of the beetle *Chrysobothris femorata* (Olivier), is present in pecan groves from spring to late fall. It attacks

FIGURE 37.—Obscure scale on pecan twig.

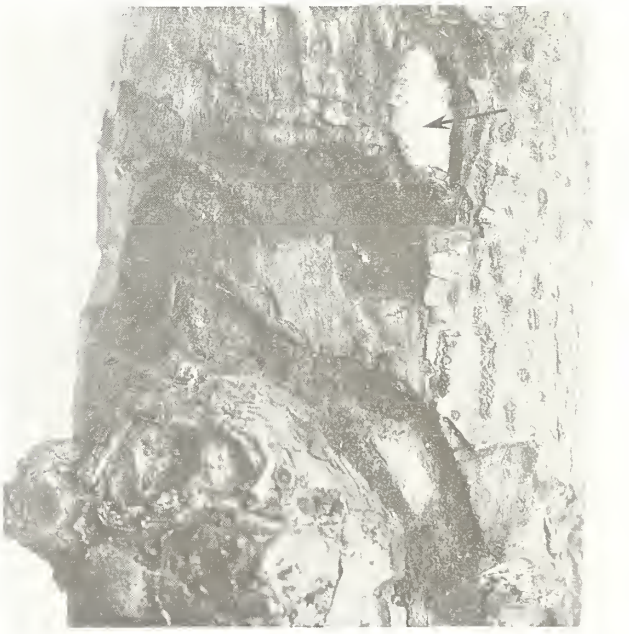

FIGURE 38.—Flatheaded appletree borer (arrow) feeding in wood of a tree.

pecan trees of nearly every age, wherever they grow. Injury is usually confined to trees weakened from some other cause, such as transplanting, mechanical injury, cold, drought, or sunscald damage.

Injury results from the larvae, or borers, tunneling in the bark and sapwood of the trunk (fig. 38). Trees 2 inches or less in diameter may be girdled and killed, and larger trees may be weakened. The presence of one borer in a tree often leads to further attack. The insects reveal their burrows by pushing frass from cracks in the bark. Injury spots can often be detected by the darker color and slight depression of the bark.

The adult beetles, about one-half inch long, are broad, flattened, and metallic colored. They lay their eggs in cracks in the bark or in injured places on the sunny parts of the tree trunks. The yellowish-white larvae are legless, with large flattened heads, and 1¼ inches long when fully grown. The insect overwinters as a borer and pupates in spring. Development from egg to adult usually requires a year.

Maintenance of tree vigor by following recommended practices of cultivation, fertilization, spraying, and soil moisture conservation helps prevent borer injury. Protect newly transplanted trees by wrapping the trunks from the ground to the lower limbs with a double thickness of newspaper, burlap, or crepe paper. Wind the wrapping spirally or vertically, and hold it in place loosely with a light cord. Apply the wrapping soon after leaves appear in spring, and leave it in place as long as it is serviceable, provided the cord does not girdle the tree.

When young trees are heavily infested, remove the borers with a knife, cutting into the bark and wood as little as possible. Hold the knife blade flat against the tree, and work along the course of the burrow; trim the edges later. Removing the bark and frass from the deeper part of the burrow will hasten healing of the wound. To keep the wood from drying until the bark heals over, paint the deeper parts with a pruning compound or a mixture of 1 part creosote and 3 parts coal tar.

Examine young trees at least once a year, preferably in March or April before mature borers emerge. If the infestation is heavy, trees should be examined during the summer and the grubs removed.

FIGURE 39.—Exit holes of adult redshouldered shothole borers.

PINHOLE AND SHOTHOLE BORERS

Several similar insect species attack weak pecan trees. Some feed only on the bark and in the cambium region, while others burrow deep into the heartwood. Occasionally they attack healthy trees, but they rarely cause serious damage since the larvae cannot subsist on wood with a good sap flow. Severe drought, mechanical damage, or cold injury often weakens trees for borer attack.

The so-called pinhole borers or scolytid ambrosia beetles, *Xyleborus affinis* Eichhoff, *X. ferrugineus* (Fabricius), and *X. saxeseni* (Ratzeburg), which inhabit the trunks and stems of many hardwood trees in the southeastern United States, also damage pecan trees. These scolytid beetles infest all sizes of pecan trees ranging from 1-year-old nursery trees to 50-year-old trees in commercial plantings. The adults are small brown to reddish-brown elongate beetles with compact cylindrical bodies about one-tenth inch long. The beetles bore holes one-sixteenth to one thirty-second inch in diameter in the pecan stem and lay their eggs in the sapwood. The entrance holes give the tree trunk or stem the appearance of having been hit by shot or pricked by pins. As the beetles construct the galleries, they push the sawdustlike borings to the outside through the entrance hole. The white C-shaped grubs feed upon fungi growing in the brood cells constructed by the

FIGURE 40.—The borings (arrows) of ambrosia beetles are very fine and sawdustlike in appearance.

FIGURE 41.—Prionus root borer in a larval gallery in pecan tree root. The larva is 2¾ inches long and weighs one-half ounce.

beetles. The associated fungi often give pecan wood a bluish-black stain.

A bostrichid beetle, the redshouldered shothole borer, *Xylobiops basilaris* (Say), makes holes one-eighth inch in diameter in the bark of pecan trees (fig. 39). These beetles, three-sixteenth inch long, have small punctures over most of the body, and the wing covers at the base of the shoulders are reddish. The beetles bore into a branch or even the trunk of a young tree, usually through or just above a leaf scar.

The first sign of borers in a tree is light sawdust particles coming from the holes (fig. 40). Some wood-attacking birds, especially sapsuckers, make holes in the trunk and limbs similar to those of wood borers. These punctures can be distinguished from insect exit holes by their larger size and spacing. Bird punctures are normally in rows and spaced in rectangular patterns.

To control borers, maintain healthy trees and reduce sources of infestation, such as dead trees and prunings. Application of a quick-acting fertilizer often assists in restoring trees if they are not too severely weakened.

PRIONUS ROOT BORERS

Larvae of two cerambycid beetles, the tile-horned prionus, *Prionus imbricornis* (Linnaeus), and the broadnecked root borer, *Prionus laticollis* (Drury), attack pecan. Early-stage larvae feed on the root bark, but soon enter the wood, completely hollowing large roots and often severing them (fig. 41). The large, fleshy, creamy-white or yellowish worms crawl through the ground from root to root, feeding on the outer surfaces of the smaller roots. Often, the hollowed roots are filled with a mixture of coarse pelletlike excrement, wood fibers, and soil. Mature larvae attain a length of 3 inches, and their feeding period may last 3 to 5 years. Severe feeding of the beetle larvae is associated with gradual limb-by-limb death of pecan trees. The foliage on dying pecan trees is irregular and thinner and lighter than that on healthy trees (fig. 42).

In early May mature larvae come within 8 to 12 inches of the soil surface and make large oval cells of compact earth and wood particles in which the pupal stage is passed. The adults (fig. 43) emerge from the soil in late spring and early summer. The beetles are broad, somewhat flattened, and blackish to reddish brown. Adults have antennae about half as long as the body and thus are appropriately called long-horned beetles.

Root borers usually attack pecan trees only when other factors such as disease, drought, mechanical damage, or soil conditions have weakened them.

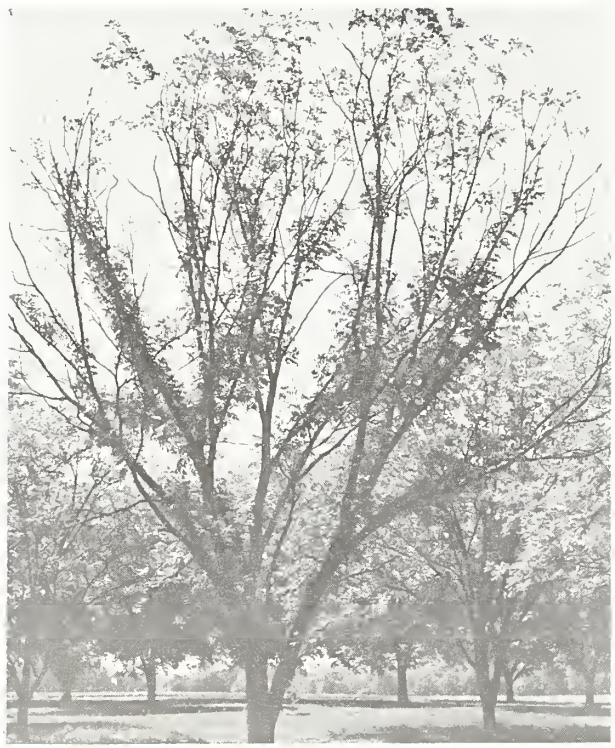

FIGURE 42.—Pecan tree infested with prionus root borers. Trees in the background show no evidence of larval damage.

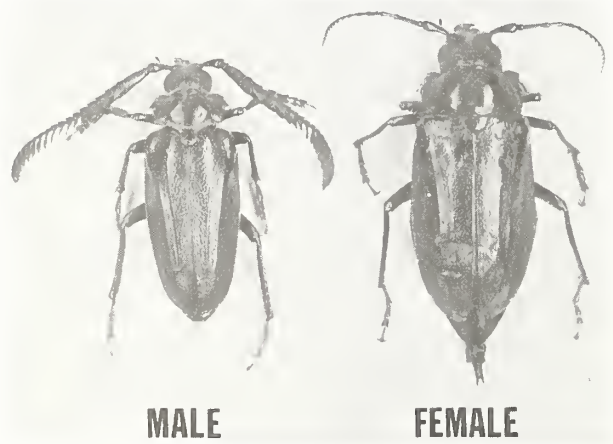

FIGURE 43.—Male and female tilehorned prionus adults. The common name refers to the segments of the male's antennae, which overlap like tiles on a roof.

TERMITES

Pecan nursery stock and small trees are sometimes killed by the feeding of termites, *Reticulitermes* spp., in the roots. These insects are known popularly as white ants or wood lice. They usually live in deadwood and injure pecan trees planted on recently cleared land containing stumps and dead roots. Affected trees may not show injury symptoms until they are damaged beyond recovery, and then they die suddenly.

Termites burrow and feed away from light; thus, their attacks on pecan trees are underground. Pecan seedlings and budded trees 1 and 2 years old are often found with the taproot or its branches tunneled, with only a shell or bark remaining (fig. 44). The feeding may extend an

FIGURE 44.—Termite injury to root of pecan nursery stock.

inch or so above ground level inside the trunk, with no external damage evident.

When planting the nursery or grove, take care to prevent termite infestations by selecting land that is free from deadwood. Recently cleared land should not be used for pecan until the dead roots and stumps have been removed. It is advisable to grow annual crops on the land for 1 or 2 years before the trees are planted. Only stakes of metal, termite-resistant wood, or wood treated with creosote should be placed by newly set trees. Untreated wood in contact with earth is quickly infested with termites, and the insects may then spread to the trees.

Pecan Diseases

SCAB

Scab, caused by the fungus *Fusicladium effusum* (Wint.), is the most damaging of pecan diseases, especially in the Southeastern States, and its control is of major importance to the industry. There are a number of pathogenic races of the scab fungus. Although many pecan varieties are resistant to some scab races, apparently none is resistant to all races. Most common pecan varieties are susceptible to scab damage, at least to some degree. Varieties such as 'Desirable', 'Farley', and 'Stuart', considered nearly immune in the past, are now susceptible to scab in many localities. Highly resistant varieties appear to be 'Curtis', 'Dependable', 'Elliott', and 'Gloria Grande'. Highly susceptible varieties, such as 'Schley' and most western varieties, can defoliate in late summer when scab is not controlled.

FIGURE 45.—Scab lesions (black spots) on leaflets of 'Schley' pecan in early spring.

Scab infection occurs if plant tissues have been wet for several hours. Primary infections can occur before mid-April and develop rapidly. Spores germinate and infect the tissues within a few hours, but lesions are not commonly seen on new tissue for 1 to 2 weeks (fig. 45). During damp weather, new crops of spores, which can cause secondary infections, are produced by late April or early May. When pecan tissues stop growing, they are usually resistant to infection. Consequently, on varieties that normally produce only one flush of growth a year (for example, 'Stuart'), nearly all leaf and stem infections take place during April and early May. Varieties that may produce summer flushes of growth (for example, 'Moore' and 'Mahan') are susceptible to leaf and stem infections later in the season. Lesions on stems and leaves are the source of spores that may later infect still-growing shucks. Nuts infected early in the season usually fall before the kernel has formed.

The primary symptom of scab is elongated olive-brown spots (lesions) on the undersides of leaves. Initially, the lesions are pinpoint size, but they may enlarge and coalesce. Later, with the development of secondary infections, large areas of the leaves may become almost black. The lesions on nut shucks are small, black, and circular; slightly raised at first, they become sunken as the shuck enlarges. Nuts of highly susceptible varieties may be so extensively infected that often most of the shuck surface appears black.

Scab injury on 'Schley' pecans is illustrated in

figure 46. Of the five nuts shown, *C* and *D* are poor in quality, but only *E* is unmarketable. Severely infected nuts may drop prematurely, or the kernels may not develop even though the nuts remain attached to the shoots.

FIGURE 46.—Nearly full-grown nuts of 'Schley' pecan classed according to degree of scab infection. *A*, No infection. *B*, One to three primary infections. *C*, Four or more primary infections. *D*, A few secondary infections. *E*, Many secondary infections.

To reduce the chance of scab infections, shake old shucks and leaf stems off before trees begin to leaf out. Failure to do this can result in infection of the foliage by rainwashed scab spores. After a rain or on foggy days, a slight jarring of branches will cause most of the old shucks and leaf stems to fall. Fungicides should be applied early in the season, beginning when buds are bursting and leaves are showing green. Recommended spray schedules should be followed closely thereafter, and the trees, especially the tops, should be thoroughly covered with the spray material. Spraying prior to rain has proved more beneficial than spraying following a rain. Most spray materials form a dry film, and respraying will not be necessary if spray material is applied at least 3 to 4 hours before a rain.

POWDERY MILDEW

Powdery mildew, caused by the fungus *Microsphaera alni* de Candolle ex Winter, appears every 4 or 5 years in most areas. This disease affects both foliage and nut shucks. The fungus forms superficial white growth (fig. 47) early in the growing season, usually apparent by July. When shucks are infected early, the nuts that develop are small, the shucks split prematurely, and the kernels shrivel. Premature defoliation of

FIGURE 47.—Early stages of powdery mildew on 'Farley' pecan nuts. The characteristic white growth has covered most of the surface of the nuts.

trees can occur when conditions are especially favorable for the spread and development of the fungus. During the winter the fungus remains dormant on infected leaves and shucks.

Powdery mildew infections, if present at all, are usually mild on trees sprayed for control of scab. If it becomes conspicuous on unsprayed trees or on sprayed trees after the normal scab spray period, apply a fungicide and make additional applications at 3- or 4-week intervals if the disease persists.

PINK MOLD

During late summer and early fall, the fungus *Cephalothecium roseum* Corda produces a pinkish growth on nut shucks (fig. 48). The pink mold fungus frequently invades shucks through scab lesions and continues to develop after the nuts have matured. The fungus may penetrate the shell and attack the kernels, causing a decay known as pink rot. Kernels affected with pink rot leak oil, giving the shell an oily appearance, and often give off a strong rancid odor.

Nuts of 'Schley' pecan, particularly those on unsprayed trees, are often seriously affected by pink mold. Even a small number of infected nuts can reduce the market value of the crop.

Pink mold attacks scab-infected nuts while nuts are still on the trees. After harvest, the mold does not spread from infected to healthy nuts. Fungicides applied for scab control will usually control pink mold.

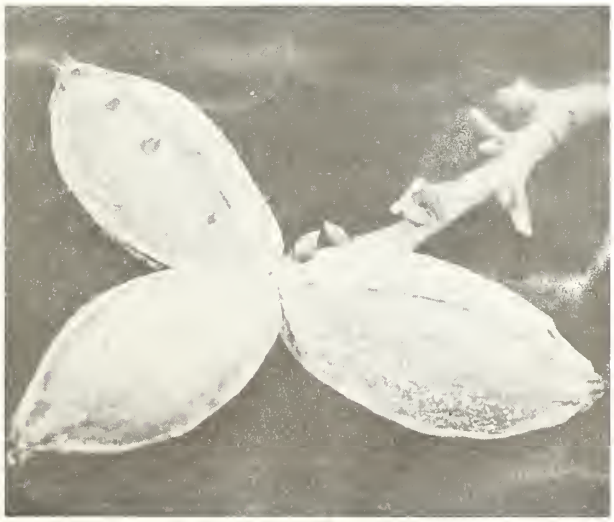

FIGURE 48.—Nuts of 'Schley' pecan affected with pink mold. Scab lesions are visible on the nut at the upper left.

SHUCK DIEBACK AND STEM-END BLIGHT

Certain pecan varieties, especially 'Success', are susceptible to a blackening of the immature nut shuck. When blackening begins at the tip of the shuck, the damaged portions of the shuck split at the sutures, flare out, and produce a symptom called shuck dieback (fig. 49). Shuck dieback is associated with a heavy nut crop and is found in

FIGURE 49.—Nuts of 'Success' pecan affected with shuck dieback. Note the blackening and shuck splitting at the terminal end of the nut.

FIGURE 50.—'Success' pecan nut with stem-end blight. Blackening occurs initially at the basal end of the nut, although eventually the entire shuck may darken.

most pecan-producing areas of the country, but the causal agent is unknown.

'Success', 'Dunstan', and 'Magenta' are highly susceptible to another condition known as stem-end blight. 'Barton' is moderately susceptible; 'Desirable', mildly susceptible; and other varieties, not wholly immune. The initial symptom is a black spot on the green shuck near the stem end (fig. 50), which may enlarge to cover the entire nut shuck. The diseased shuck tends to cling to the nut, producing a "sticktight." If stem-end blight is widespread early in August, most of the nut crop will be worthless. The causal agent of this affliction is also unknown.

Stem-end blight occurs predominantly in the Red River Valley and in the Mississippi River

FIGURE 51.—White "frosty" spots on the underside of a pecan leaflet are characteristic of downy spot disease in its early stages.

FIGURE 52.—Vein spot disease on a pecan leaflet. Spots are dark brown or black in the final stages of the disease.

Valley bordering Louisiana and Mississippi. Because symptoms of both shuck dieback and stem-end blight are often found in the same grove, the diseases were collectively referred to as shuck disease in the past. There is no chemical control for either disease.

DOWNY SPOT

Downy spot, caused by the fungus *Mycosphaerella caryigena* Demaree & Cole, affects pecans throughout the southern Pecan Belt. Symptoms appear in late spring or early summer as downy, or "frosty," spots (aggregations of fungal spores) on the underside of leaflets (fig. 51). Later, after the spores have been washed away or have deteriorated, greenish-yellow spots, about one-eighth inch in diameter, are visible on both sides of the leaves. As the season advances, diseased tissues turn brown and die. Heavily infected trees defoliate prematurely.

'Burkett', 'Moneymaker', and 'Stuart' are among the varieties most susceptible to downy spot, although no variety is immune. Downy spot seems to be more severe in river bottoms, possibly because of higher humidity.

Most fungicides effective in scab control also control downy spot. They are effective only when leaves are growing, in April and early May. Varieties that produce midsummer growth flushes should be observed carefully and sprayed if necessary. Two or three spray applications usually give adequate control.

VEIN SPOT

Vein spot, caused by the fungus *Gnomonia nerviseda* Cole, is a disease of pecan leaves and does not occur on shoots or nuts. It is found in many parts of the Pecan Belt and is especially prevalent in Arkansas, Louisiana, Mississippi, Oklahoma, and Texas.

The fungus apparently invades the area adjacent to the veins on leaflets (fig. 52). Vein spot lesions are similar to those of scab disease and may easily be mistaken for scab. The spots characterizing both diseases may originate on the veins of leaflets or on leaf stems (rachises), and both kinds of spots are dark brown or black in the final stages. On lateral veins, however, vein spot lesions seldom attain a diameter of more than one-fourth inch, whereas scab lesions grow to much larger proportions. Vein spot lesions on midrib veins sometimes extend from the base to the apex of the leaflet.

Generations of spores infect expanding leaves in early spring or new leaves of a second growth flush in midsummer. Because the vein spot fungus occurs on growing tissues, premature defoliation can follow even moderate infections. Vein spot sometimes causes severe defoliation, but often only leaflets, rather than entire leaves, fall, leaving a leaf skeleton.

Fungicides and the timing of spray applications for control of vein spot are the same as those for downy spot.

LIVER SPOT

In some years, the fungus *Gnomonia caryae* Wolf var. *pecanae* Cole causes considerable damage to pecan foliage in Arkansas, Georgia, Louisiana, Mississippi, and Texas. The symptoms of the disease, known as liver spot, first appear in May or June as dark-brown (liver-colored) circular spots, one-eighth to five-eighths inch in diameter, on the lower surfaces of the leaflets, mainly along each side of the midrib (fig. 53). The fungus apparently prefers the lush foliage of healthy trees. In September and October the color changes to cinnamon brown, and at about the same time, small, dark, spore-bearing bodies appear in the center of the spots. Leaflets infected with numerous spots drop during September or October. If spring weather is damp and favorable for numerous infections, severe defoliation may occur early in autumn.

Liver spot may be controlled with fungicide applications beginning in late April, 3 to 4 weeks after bud emergence, and followed by two or three subsequent applications at 2-week intervals.

LEAF BLOTCH

Leaf blotch is caused by the fungus *Mycosphaerella dendroides* (Cooke) Demaree & Cole. It is present throughout most of the Pecan Belt and attacks both young and mature trees. In June or July, velvety olive-green tufts of conidiophores and spores begin to appear on the underside of leaves on lower branches (fig. 54). Later, yellow spots appear on the upper surface of the leaves, followed in midsummer by the appearance of fruiting bodies, black pimplelike structures. When the spores have been washed away or have otherwise deteriorated, groups of

fruiting bodies unite, giving the leaflets a shiny black blotched appearance. Occasionally, these blotches join to envelop entire leaflets, causing premature defoliation of the tree.

The fungus that causes leaf blotch is a weak parasite that attacks pecan trees only when they have been lowered in vigor by overcrowding, lack of fertilization, borer attack, or general neglect. Nursery trees are highly susceptible, and the disease is prevalent where nursery blight is present.

To control leaf blotch, spray trees with a fungicide beginning the second or third week in May, about a week after bloom. One or two additional applications at 2- to 3-week intervals may be necessary for good control.

FIGURE 53.—Early stages of liver spot on a pecan leaflet.

FIGURE 54.—Early stage of leaf blotch on the underside of a pecan leaflet. The pimplelike fruiting bodies have just begun to form dark blotches.

BROWN LEAF SPOT

Brown leaf spot, caused by the fungus *Cercospora fusca* Rands, can prematurely defoliate pecan trees. Although found throughout the Pecan Belt, it is more prevalent in humid areas. Neglected trees low in vigor or those not sprayed with a fungicide are apt to be seriously damaged.

FIGURE 55.—Brown leaf spot on the underside of a pecan leaflet. The diseased spots are often characterized by concentric markings (not visible in photograph).

Brown leaf spot first appears in June or July and is found only on mature leaves. Primary infections are reddish brown and circular (fig. 55), and they may develop grayish concentric zones. As the disease progresses, the spots become irregular in outline. If not controlled, the disease can cause complete defoliation in late September. Like other leaf fungi, the brown leaf spot fungus overwinters in infected spots on old leaves.

To control brown leaf spot, spray trees with a fungicide, timing the sprays as for leaf blotch.

NURSERY BLIGHT

Nursery blight, caused by the fungus *Elsinoe randii* Jenkins & Bit., is, as the name implies, almost entirely confined to nursery trees. Seedlings severely affected by nursery blight grow slowly and are often too small for budding at the end of the second season.

The fungus invades both young and old leaflets. Infections begin in April, developing into small reddish lesions on both surfaces (fig. 56). Later in the season, spots on the upper surface turn gray. Single lesions are usually about one-eighth inch in diameter. These spots may be united by secondary infections to form a continuous lesion along each side of a vein. Secondary, or late, infections are most numerous along the midribs and larger veins. The diseased areas are soon destroyed by the invading fungi, and the affected leaflets then have ragged margins and perforations.

To control nursery blight, spray trees with a suitable fungicide at 3- to 4-week intervals, beginning when the first leaves are half grown.

ZONATE LEAF SPOT

Zonate leaf spot, caused by the fungus *Cristulariella pyramidalis* Waterman & Marshall, was first observed on pecans in Alabama and Georgia in 1967 and in Florida in 1970. It is easily recognized because symptoms on leaflets are strikingly different from those of other leaf-spotting fungus diseases of pecan. Lesions on the upper surface of leaflets are grayish brown, with conspicuous lighter colored concentric rings (fig. 57). On the lower surfaces of leaflets, the lesions are a less distinct light brown to tan. The same fungus produces similar symptoms on various species of maple, box elder, butternut, magnolia, and sassafras from New England southward.

Development of zonate leaf spot is favored by cool moist weather in late summer.

An obvious control for zonate leaf spot is isolation of pecan groves from woodlots that contain other host trees of the species. In established groves, fungicidal sprays should be used from late July to September. Since this is later than most pecan growers spray to control scab, additional fungicidal spray applications are necessary to retain foliage.

BUNCH DISEASE

The characteristic symptom of bunch disease is a bushy growth of slender willowy shoots, resulting from an abnormal forcing of lateral buds into growth. Bunch disease is reported to be caused by an undetermined virus, but this has not been irrefutably confirmed. Seriously affected trees become mere skeletons, with a thick broomy sucker growth covering main lateral branches. Symptoms can appear on a portion of a branch or on scattered branches of lightly affected trees. Bunch disease is most conspicuous in spring and early summer since affected shoots foliate earlier than healthy branches (fig. 58). There is evidence that the spread of bunch disease is favored by wet weather during flushes of growth; mild symptoms are often difficult to recognize in dry weather.

FIGURE 56.—Early stages of nursery blight on a pecan leaflet.

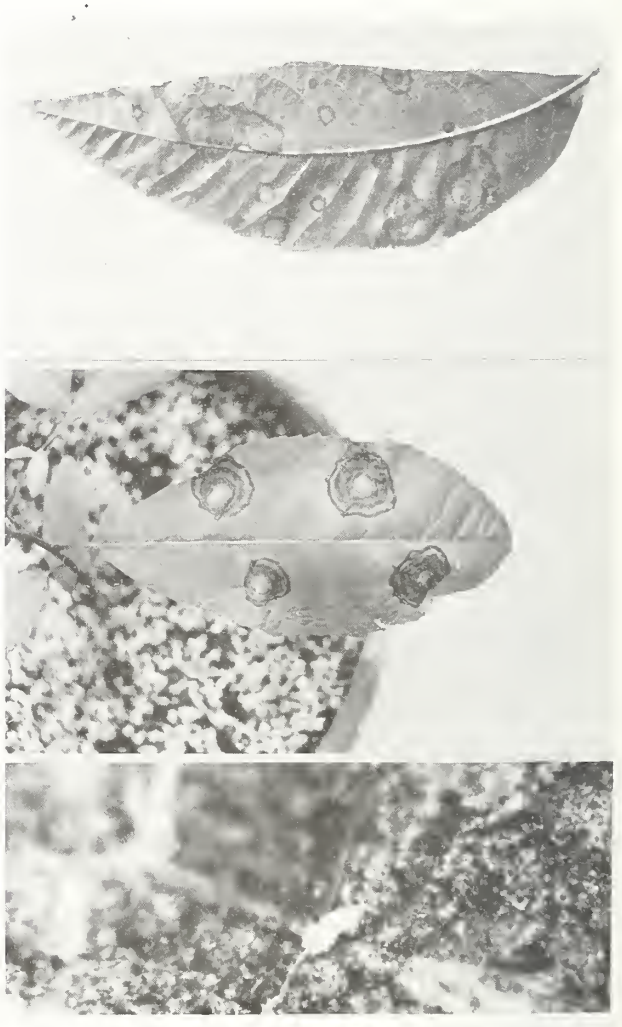

FIGURE 57.—Zonate leaf spot on pecan leaflets. *Top*, Zonate damage on the underside of a mature pecan leaflet. *Center*, Distinct concentric ring pattern caused by the organism on the upper surface of a pecan seedling leaflet. *Bottom*, Sporophores of the disease organism, *Cristulariella pyramidalis*, on the surface of a pecan leaflet.

Bunch disease may be mistaken for rosette, caused by zinc deficiency, because bunching of foliage and early foliation are characteristic of both diseases. Unlike bunch disease, rosette also manifests itself in the leaflets, which crinkle and turn yellow between the veins.

Bunch disease occurs on pecans from Georgia to New Mexico and north to Kansas. However, many upland pecan groves are well isolated from sources of infection. Similar disease symptoms occur on several other hardwood species, but the range of these host species is unknown. 'Brooks', 'Caddo', 'Choctaw', 'Curtis', 'Farley', 'Gloria Grande', 'Mohawk', 'Moreland', 'Owens', 'San Saba Improved', 'Seminole', and 'Stuart' are apparently highly resistant to bunch disease, while 'Cape Fear', 'Forkert', 'Jackson', 'Moore', and 'Natchez' are moderately resistant. 'Barton', 'Burkett', 'Dependable', 'Desirable', 'Elliott', 'Mahan', 'Schley', 'Texhan', and 'Western Schley' are highly susceptible. Diseased trees have been successfully topworked to resistant varieties.

FIGURE 58.—Effects of bunch disease on a pecan tree in early spring. Diseased branches often put out leaves about 2 weeks earlier than healthy branches.

ROSETTE (ZINC DEFICIENCY)

Rosette is not a disease caused by a pathogenic organism, but a nutritional disorder caused by zinc deficiency. It occurs when the zinc content of soil is low or when zinc cannot be absorbed by tree roots. In 1931, when the cause and control of rosette were discovered, most bearing pecan trees in the Southeastern States were affected by the disease. Since that time, the soils of most Southeastern pecan groves have been treated with zinc sulfate, and it is less of a problem. Once rosette is controlled, it is a minor problem, and only an occasional application of zinc sulfate is needed.

Symptoms of zinc deficiency in pecans are often confused with pathogenic diseases, particularly bunch disease. The earliest symptom of rosette is a yellowish mottling of the leaves, particularly in the treetops. Leaflets with advanced disease symptoms are slightly narrowed and crinkled. As the disease progresses, the leaflets become reddish brown or perforated between the veins, new shoot growth is checked, internodes are shortened, and foliage is bunched, or rosetted (fig. 59). The symptoms become more pronounced as the season advances, and by October or November the trees appear at their worst, with foliage appearing rusty, or bronzed.

FIGURE 59.—Pecan tree seriously affected with rosette. Dead branches can be seen at top of the tree. Leaflets on other branches are small, narrowed, curled, and yellowish green.

The final symptom of rosette is dieback of shoots from the tips. Dieback is usually confined to the current year's growth, but it sometimes extends to older branches of considerable size. Seriously affected trees rarely bear a good crop, and if they do, the nuts are usually small and poorly filled.

Rosette occurs under various soil conditions throughout areas where pecans are grown, and it is common in young groves intercropped annually with cotton, corn, or peanuts. The following soil conditions are most commonly associated with rosette: Lime-impregnated sandy loam, loamy sand, and deep sandy soils deficient in organic matter; eroded soils with little or no surface soil remaining; and fertile soils that have been deeply and frequently cultivated or that have received too much fertilizer, especially nitrogen, phosphorus, or lime. Rosette is especially common on alkaline irrigated soils of the Southwest.

Rosette may be corrected by spraying zinc sulfate on the trees or by applying the dry salt on the soil. Spraying results in more rapid recovery from rosette, but soil applications (on certain soil types) last longer.

Zinc sulfate alone or with compatible spray chemicals is applied at the rate of 2 to 3 pounds per 100 gallons (about 20 gallons of solution delivered per medium-sized tree) with ground spray equipment or at 5 to 6 pounds in 20 gallons of water per acre by airplane. Applications should be made early, in April and May, when leaves are expanding. Midsummer applications can be effective on young, actively growing trees. Several spray applications are often necessary to eliminate severe rosette. When symptoms do not recur annually, two annual applications are generally adequate to prevent recurrence, the first late in April and the second in mid-May.

Applications of zinc sulfate to the soil are usually effective on acid, neutral, and light-textured alkaline soils. Zinc sulfate can be applied in conjunction with complete fertilizer mixes at the rate of 5 pounds zinc sulfate per tree. Severely rosetted trees require between 5 and 10 pounds of zinc sulfate annually for 2 or more years. Zinc sulfate may be applied in the fall before a winter cover crop is seeded. When applied in spring with a cover crop present, it should be spread evenly under the limbs of the trees, and disking should be delayed to avoid injury to the cover crop.

Sometimes growers are tempted to routinely apply zinc because they think it may benefit their pecan trees even when rosette symptoms are not apparent. This should be avoided. When in doubt about the nutritional status of your grove, have a leaf sample taken for analysis. Check with the

FIGURE 60.—Crown gall disease on nursery stock. Infected trees should be burned to prevent further spread of the disease.

FIGURE 61.—Twenty-year-old pecan tree completely girdled by the large wartlike growth known as crown gall.

county agent or State extension specialist, who will describe the sampling procedure, analyze the tissue, interpret the results, and recommend a fertilizer program. Overfertilization with zinc can poison trees.

CROWN GALL

Crown gall, caused by the bacterium *Agrobacterium tumefaciens* E. F. Smith & Townsend, often damages pecan trees. It was formerly believed that crown gall affected only nursery trees (fig. 60), but in recent years the disease has been found on old trees in established groves (fig. 61).

On mature trees, crown gall is confined primarily to large roots and bases of the trunks, but occasionally smaller roots are also infected. Wartlike growths of disorganized tissues, from a few inches to a foot or more in diameter, often extending several inches above the soil surface, characterize development of crown gall. The galls are often broken off from the roots and scattered by cultivation, thus spreading the disease.

Nursery trees infected with crown gall should be burned at the time they are dug. Plant only disease-free trees in new groves. Avoid cultivation or mowing near the trunks of infected trees; these practices can spread the disease. Chemical control may be necessary.

FIGURE 62.—Sporophores of *Clitocybe tabescens* at the base of a pecan tree.

CLITOCYBE ROOT ROT

Observers in Georgia have expressed fear that root rot caused by the fungus *Clitocybe tabescens* (Scop. ex Fr.) Bres. may be a widespread disease of pecan since it is a serious disease of peaches there. Apart from stunting the trees, the symptoms are not obvious, even after much of the root system has been destroyed. Diseased roots have a layer of white or creamy mycelium beneath the bark. The fruiting body, or sporophore, of the fungus is a mushroom that appears in clusters near the base of a tree or on deadwood on the tree (fig. 62). The fungus has many hosts, including hickory, peach, oak, elm, and pine trees.

Avoid planting pecan trees on recently cleared forest land and on land where peach trees have had a history of *Clitocybe* root rot. Once trees are diseased, there is no known control measure.

PHYMATOTRICHUM ROOT ROT

Phymatotrichum root rot, also called cotton root rot, is caused by a soil-inhabiting fungus, *Phymatotrichum omnivorum* (Shear) Duggar, which infects over 1,700 species of plants. The disease has been found in Mexico and in Texas and other States westward to the Pacific coast.

The fungus is most active during summer. Root injury restricts moisture and nutrient supply to the tops of pecan trees, eventually causing death. Diseased trees have a sparse yellow foliage for 1 or 2 years, after which they usually die.

There is no practical control. Pecan trees should not be planted where cotton and alfalfa have been grown and where soil is known to be infested with this fungus.

TUMOR DISEASE

Tumor disease attracts little attention because it is rarely damaging in groves under 30 years old and then only if trees of susceptible varieties are exposed to infections. Its spread is usually slow, but the disease has eliminated many 'Schley' trees in old groves in the Red River Valley and the humid Mississippi Valley. The causal organism has not been identified.

The characteristic symptom is rough swellings on the trunk and main limbs of old pecan trees (fig. 63). These tumors, less than 1 inch to several

FIGURE 63.—Established tumors (arrows) on a mature 'Schley' pecan tree. Note the loose sloughing bark.

inches in diameter, are composed of disorganized tissues resembling galls. Large tumors, often surrounded by numerous small ones, occur most often at crotches of trees, rendering them weak and susceptible to breakage. As the tumors increase in number, the tree is gradually girdled; large scaffold limbs die, and the tree often dies. Damage from tumor disease can attract insect borers, which in turn attract wood-rot fungi.

There is strong correlation between looseness of sloughing bark on old trees and the susceptibility of pecan varieties to tumor disease. 'Burkett', 'Schley', and 'Teche' are mong the most susceptible; 'Alley', 'Bradley', 'Curtis', 'Moneymaker', 'Pabst', and 'Success' are moderately susceptible; 'Desirable' and 'Stuart' appear to be nearly immune.

Tumor disease is more prevalent in groves where trees have been topworked and in groves flanked by woods. New pecan trees should be planted several hundred yards from any other orchard, woodlot, or ornamental planting. There is no chemical control.

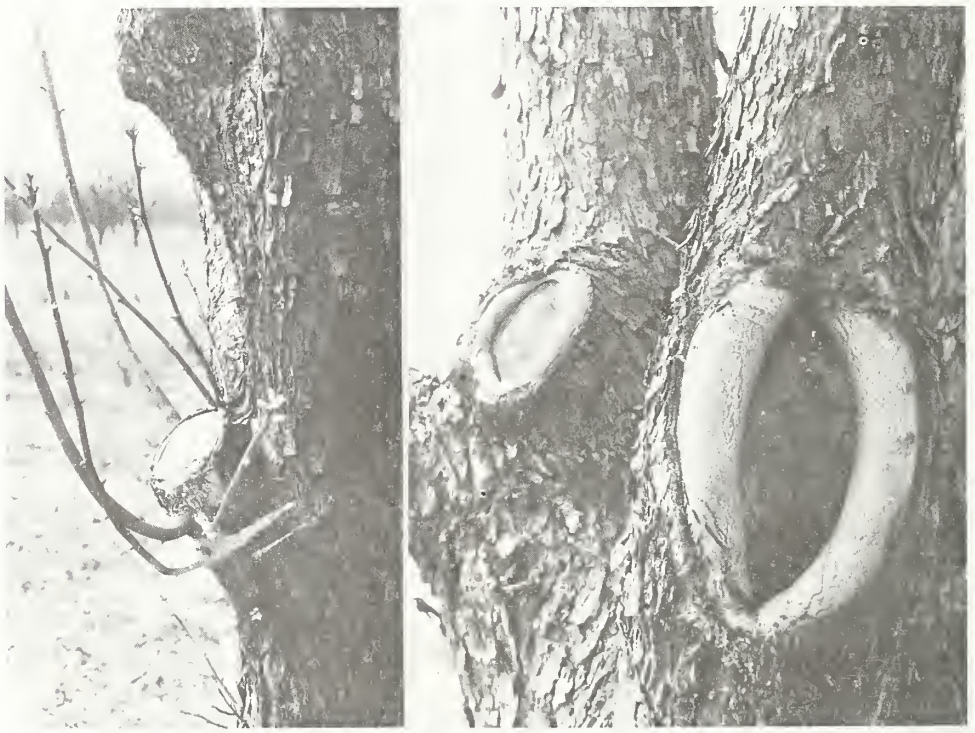

FIGURE 64.—Tree at left was improperly pruned. Wounds of this type heal slowly and provide entrances for wood-rotting fungi. Tree at right was pruned properly, and it healed rapidly. Cuts were made flush with trunk and then treated with the recommended mixture of coal tar and creosote.

WOOD ROT

Broken branches and other wounds on pecan trees are entry points for wood-rotting fungi unless injured surfaces are properly treated. Once wood-rot fungi gain entrance, they spread rapidly through the wood and may destroy the entire tree.

Broken branches or limbs should be cut off flush with the main branches or trunk (fig. 64). Do not leave projecting stubs; they rarely heal over and continue to provide entrances for wood-rotting fungi. Paint the wounds with commercial tree wound paints containing asphalt, tar, or vegetable gums as their base. Repeat this treatment once a year until wounds have healed. Some of these materials may slightly injure the cambium (growing layer), but the wounds will usually remain free of wood-rotting fungi and eventually heal.

CYTOSPORA CANKER

Damage resulting from nonpathogenic causes can lead to secondary infections by various pathogens such as wood-rot fungi. Growers may erroneously conclude that the pathogen was the primary cause of disease. This was the case in southern Arizona in the spring of 1969 when young pecan trees failed to leaf out.

The tree trunks had been girdled, and numerous cankers were observed on scaffold and smaller limbs. Orange masses of spores associated with a *Cytospora* fungi were visible in long tendrils in the cankered areas. This disease was scattered throughout a 4,000-acre planting, but it occurred primarily on 2- and 3-year-old 'Barton', 'Bradley', and 'Western Schley' pecan trees. 'Riverside' pecans, used as a rootstock, appeared to be disease free.

The most likely factors contributing to fungal infection were low-temperature damage during the winter, a late spring frost in 1968, summer sunburn, pruning injuries, or herbicide injury. The original fungal inoculum probably came from nearby diseased native trees such as cottonwood. Newly planted healthy trees were disease free.

There are no control measures except to keep trees healthy and free from mechanical and weather damage. See sections on winter injury and sunscald for these control measures.

Injuries Leading to Disease

WINTER INJURY

Winter or cold injury is usually found on young, vigorous, late-growing pecan trees. It generally occurs on trees that have prematurely lost their leaves and then have put out new leaves late in the growing season. If such trees have not become dormant before freezing weather, their growing tissue is likely to be injured, particularly near the base of the trunk. Early the next spring, severely damaged trees usually leaf out and appear to grow normally. With the advent of hot weather, however, the leaves wither, and the trees suddenly die.

Winter injury is easily detected. The bark on the injured area appears sunken and is cracked where it meets the growing tissue, which is discolored and sour smelling. The roots of injured trees seldom die, but sprout from below the dead trunks. Insects and disease organisms sometimes invade winter-injured trees, causing secondary damage.

Disease and insect control, shallow cultivation, and proper fertilization help prevent winter injury. Spraying to control disease and leaf-destroying insects is the most important preventative measure. Trees that defoliate in late summer usually will go into a second growth cycle and be susceptible to an early freeze. Cultivation should not ordinarily be continued past midsummer. Groves are often cultivated preparatory to planting winter cover crops in fall, but this practice should be discontinued if winter injury is prevalent in the grove. Trees should not be fertilized or irrigated late in the fall when they are still in leaf. If these practices are followed, trees will escape premature defoliation and go into winter in a hardy condition.

SUNSCALD

Injury from direct sunlight is sometimes confused with winter injury. Sunscald symptoms are dead or cankerous areas, usually on the southwest side of the trunk or on the upper surfaces of large branches. Like winter injury, sunscald occurs mostly on young trees, but it can be found on older ones that have been cut back for topworking to some other variety.

Heat from bright sunshine, which raises the temperature of unshaded bark to a damaging level, is probably the sole cause of sunscald in summer. Bright sunlight during winter days followed by sudden temperature drops at night can also severely damage major limbs and tree trunks. If warming stimulates activity in the active growth zone, the cells that break dormancy can be destroyed when freezing temperatures follow. Dead areas underneath the bark furnish ideal entry points for borers, other insects, and wood-rotting fungi.

Materials that reflect or otherwise reduce the sun's heating effect should be applied to trunks to protect young trees against sun damage in both summer and winter. These might include cloth, paper, aluminum foil, and a nontoxic whitewash or paint.

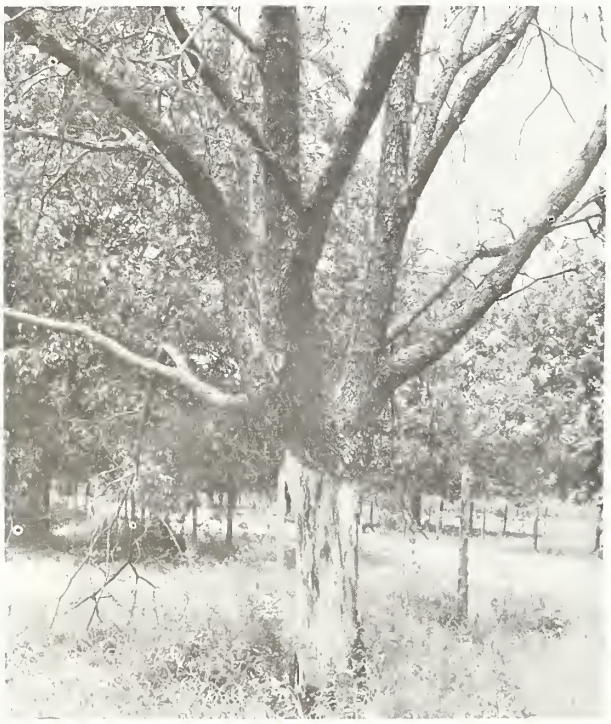

FIGURE 65.—Pecan tree killed by lightning, shown as it appeared 3 months after having been struck. Note how the bark was stripped from the trunk.

LIGHTNING INJURY

Lightning often strikes pecan trees, causing injury or even death. The principal visible injury may be confined either to the limbs and branches or to the trunk, or there may be a narrow split in the bark extending from a branch down along the trunk to the ground. The bark frequently peels from the trunk, especially near the ground (fig. 65). When the bark is only split (fig. 66), the tree usually survives, but if the bark loosens or peels from the trunk, the tree will usually die within a few weeks.

Trees struck by lightning usually undergo partial to complete defoliation, depending on the extent of injury. Leaves of affected areas first turn yellow, and complete defoliation can occur within 30 to 60 days.

There is no practical way to prevent lightning damage in a grove. If a tree is killed, it should be destroyed or it may become infested with insect borers that may spread to other trees. Injured trees should be treated promptly. Dead limbs should be removed. Pruning wounds and bark cracks should be treated with both an insecticide and fungicide, then painted with a commercial tree paint as recommended for the control of wood rot. Most lightly injured trees, properly cared for, eventually recover.

FIGURE 66.—The bark of the trunk of this tree was split to the ground by lightning. Some of the branches died in about 4 weeks, but the rest of the tree later recovered.

MECHANICAL DAMAGE

Mowers, disks, or other implements frequently tear away bark and leave exposed wounds. Mechanical tree shakers, when used improperly, can separate the bark from the wood at the cambium (growth layer). The damage is not usually noticeable, however, and these portions of trunk and limbs are susceptible to winter injury. The following year, water accumulation beneath the bark is observable as wet spots on the trunk or limbs. Disease and insects then invade the damaged area, and the infection can expand until the tree dies.

When shaker-type damage is noted, the dead bark should be chipped away and the area treated with proper fungicides and insecticides prior to painting the wound. Open wounds caused by mowers and disks should be treated immediately with commercial tree wound paints.

Nonparasitic Plants on Limbs and Bark

SPANISH-MOSS

Spanish-moss, *Tillandsia usneoides* Linn., is a troublesome, unsightly growth in some pecan groves along the gulf coast and in other areas where humidity remains high. Spanish-moss is an epiphytic plant; that is, it grows nonparasitically on trees, obtaining its nourishment from air, rain, and dew. Large accumulations of Spanish-moss are detrimental because they shade the pecan foliage (fig. 67).

Cultural practices that lead to vigorous pecan trees, providing a dense shade, will usually restrict the growth of Spanish-moss, which requires strong sunlight. Once the pest is established, chemical control is necessary.

FIGURE 67.—Accumulation of Spanish-moss on a pecan tree.

LICHENS

Lichens frequently grow on the trunks and branches of pecans, usually in the humid climate

FIGURE 68.—Lichens on bark of pecan tree branch.

of the gulf coast. These growths give trees an unkempt appearance, but they are usually harmless. No control is recommended. Although not parasitic themselves, lichens are sometimes mistaken for harmful parasites.

Lichens are not single plants, but composite organisms made up of algae in enveloping meshes of fungus filaments. Like Spanish-moss, lichens obtain their food chiefly from air and water. They attach themselves not only to trees (trunks, branches, and occasionally leaves), but also to such inanimate objects as fenceposts and rocks.

The grayish-green paperlike growth that occurs on the bark of pecan trees (fig. 68) is a common lichen. This irregularly shaped growth varies from nearly an inch to several inches across. Its edges are usually lobed and curled upward.

Key to Pecan Insects and Diseases

INSECTS INJURING NUTS

Creamy to dirty-white caterpillars up to one-half inch long feeding in immature nuts. Later in the season, after shells harden, larvae tunnel in the shucks..... HICKORY SHUCKWORM and PECAN BUD MOTH

Olive-green caterpillars up to one-half inch long feeding in nuts, often webbing them together. Later in the season larvae tunnel in the shucks ..... PECAN NUT CASEBEARER

Brown beetles about one-half inch long, with long beaks, feeding and laying eggs on the green developing nut.

White legless grubs up to three-fifths inch long feeding in nuts in late summer after shells harden..... PECAN WEEVIL

Green or brown shield-shaped bugs up to five-eighths inch long sucking sap from developing kernels ..... STINK BUGS and other PLANT BUGS

White legless grubs up to one-fourth inch long feeding in newly formed nuts prior to shell hardening ..... NUT CURCULIO

Masses of frothy white foam containing tiny light-green insects—on buds, shoots, and nut clusters ..... SPITTLEBUGS

INSECTS INJURING FOLIAGE AND SHOOTS

Tiny ($^1/_{16}$-inch-long) black sucking insects causing yellow blotches on foliage ... BLACK PECAN APHID

Tiny ($^1/_{16}$-inch-long) yellow soft-bodied sucking insects producing honeydew ..... YELLOW APHIDS

Masses of frothy white foam containing tiny light-green insects—on buds, shoots, and nut clusters ..... SPITTLEBUGS

Woolly caterpillars in large white silken webs often enclosing entire branches ..... FALL WEBWORM

Caterpillars with long dirty-white hairs feeding in colonies on foliage without forming webs ..... WALNUT CATERPILLAR

Greenish caterpillars, one-half inch long, feeding on leaves and in terminals and axils of buds ..... PECAN BUD MOTH

Tiny caterpillars in light-brown cigar-shaped cases about one-fourth inch long ..... PECAN CIGAR CASEBEARER

Olive-green caterpillars up to one-half inch long tunneling in terminal buds and shoots in early spring ..... PECAN NUT CASEBEARER

Dark-green caterpillars feeding in small gray cases, about one-half inch long, in spring. In summer and fall they produce small winding blotches in the leaves ..... PECAN LEAF CASEBEARER

Tiny caterpillars, up to one-fifth inch long, inside the leaves in thread-shaped, trumpet-shaped, or irregular-shaped tunnels ..... LEAFMINERS

Active dark-gray caterpillars up to 3 inches long feeding on foliage in early spring ..... PECAN CATOCALAS

Very tiny green arthropods feeding on the underside of leaves near veins, midrib, and leaf margins. Infested leaves often appear scorched ..... MITES

Galls or tumorlike swellings on leaves, twigs, and nuts, containing numerous small soft-bodied insects ..... PHYLLOXERAS

Gray or tan beetles up to one-half inch long feeding on foliage at night ..... MAY BEETLES

Spiny light-green caterpillars feeding on foliage in early spring. Their feeding gives a "shothole" or "lacy" appearance to foliage ..... SAWFLIES

White legless grubs up to three-sixteenths inch long feeding within newly formed shoots ..... HICKORY SHOOT CURCULIO

INSECTS INJURING TWIGS, BRANCHES, AND TRUNK

Grayish-brown beetle about one-half inch long girdling twigs and branches in late summer and fall ..... TWIG GIRDLER

Branches encrusted with a circular scalelike substance, one-eighth inch in diameter, which closely resembles the color of bark	OBSCURE SCALE
Yellowish-white legless borers with large flattened heads tunneling underneath the bark of trunk and branches	FLATHEADED APPLETREE BORER
Holes about one thirty-second to one-eighth inch in diameter in dying branches and trunk	REDSHOULDERED SHOTHOLE BORER and PINHOLE BORERS

INSECTS INJURING ROOTS

Large fleshy white larvae up to 3 inches long tunneling in roots	PRIONUS ROOT BORERS
White antlike insects tunneling within roots	TERMITES

DISEASES OF NUTS

Small black circular lesions that become sunken and enlarge as shucks grow. Observable by early summer	SCAB
White powdery film on shucks, apparent by July, resulting in small nuts that open prematurely	POWDERY MILDEW
Pinkish growth on shucks in late summer. Nuts with oily shells	PINK MOLD
Blackening and splitting of immature shucks; "sticktights." Observable by midsummer	SHUCK DIEBACK and STEM-END BLIGHT

DISEASES OF LEAVES

Olive-brown spots on undersides of leaflets in late spring	SCAB
White or "frosty" spots on undersides of leaflets in late spring	DOWNY SPOT
Dark-brown to black lesions on veins and stems of leaflets on new growth in spring or summer flush growth	VEIN SPOT
Small liver-colored circular spots along main vein underside of leaflets; first appear in early summer	LIVER SPOT

Velvety olive-green tufts in early summer; in midsummer, yellow spots with black pimplelike dots on upper surfaces of leaflets ..... LEAF BLOTCH

Reddish-brown circular spots with grayish concentric lines on mature leaflets in June or July ..... BROWN LEAF SPOT

On nursery trees, small reddish lesions on both leaflet surfaces in April; later, spots on upper surface turn gray ..... NURSERY BLIGHT

Grayish-brown lesions on upper surfaces of leaflets, with conspicuous lighter colored concentric rings; observed in late summer ..... ZONATE LEAF SPOT

Bushy sucker growth on terminals of main lateral branches ..... BUNCH DISEASE

Yellowish leaf mottling, mainly in treetops, in early summer. Narrowed and crinkled leaves with reddish-brown spots and perforations by late summer ..... ROSETTE (ZINC DEFICIENCY)

DISEASES OF ROOTS

Disorganized tissues in large tumors extending underground from the base of trunk ..... CROWN GALL

Stunted trees, mushrooms around tree near trunk in late summer, white mycelium beneath bark of roots ..... *CLITOCYBE* ROOT ROT

Poor tree growth, yellow and sparse leaves, dead or rotting roots; seen in midsummer ..... *PHYMATOTRICHUM* ROOT ROT

DISEASES OF OR DAMAGE TO TRUNK AND LIMBS

Rough swellings on trunk and limbs similar to those of crown gall ..... TUMOR DISEASE

Pruning wounds or ragged broken branches where wood rots ..... WOOD ROT

Orange masses of spores in long tendrils associated with cankers ..... *CYTOSPORA* CANKER

Trees leaf out in spring and suddenly leaves wither and tree dies; usually young trees ..... WINTER INJURY

Dead or cankerous areas on southwest side of trunk or main limbs; usually observed on young trees in spring ..... SUNSCALD

Narrow splitting or peeling of the bark extending along main limb down trunk to ground. Usually a partial defoliation shortly after damage. Observed shortly after lightning strike ..... LIGHTNING INJURY

Splitting bark and oozing wet spots on trunk or main limbs similar to lightning damage ..... MECHANICAL DAMAGE

NONPARASITIC PLANTS ON LIMBS AND BARK

Accumulations of grayish-green moss hanging from limbs ..... SPANISH-MOSS

Whitish-gray mosslike masses on bark ..... LICHENS

Index

Latin names are cross-referenced to common names, if any, to which the reader should refer.

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